National Aeronautics and Space Administration

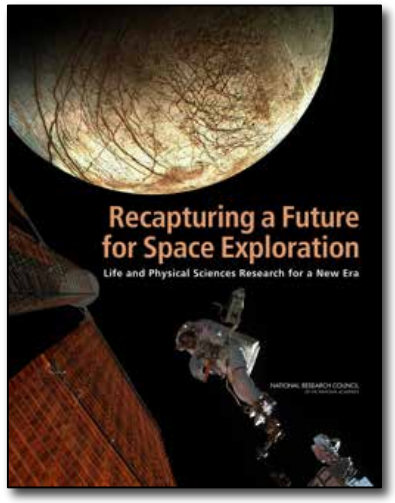
NASA

EXPLORE SCIENCE

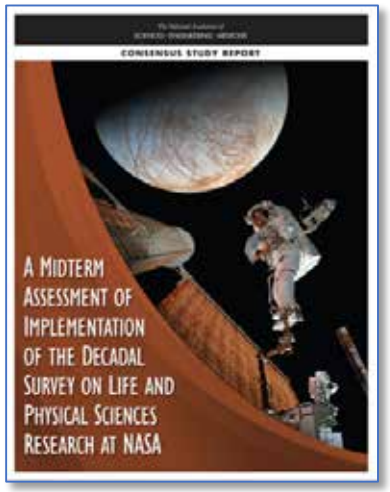
# What are Research Campaigns? – A Bold New Concept for the Future of Biological and Physical Sciences Research in Space

Craig Kundrot
Biological and Physical Sciences Division
Science Mission Directorate
September 29, 2020

# Why Research Campaigns?




*Decadal Survey*




*Midterm Assessment*

- Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era (2011)
  - 65 highest priority recommendations
  - Top level research timeline for many disciplines
- Implementation challenges for NASA
  - What is in scope? Out of scope?
  - Is there a goal? Should there be a goal?
- Research Campaigns
  - Well-defined content
    - Not focused on a single “Keystone” mission
  - Clear, transformative goal
    - Spaceflight applications typically matured to Technology Readiness Level 6: System/sub-system model or prototype demonstration in a relevant environment

# Research Campaigns

- The following examples
  - Illustrate *some* of the many possible approaches to formulating Research Campaigns
  - Are notional and over-simplified
- The following examples are not prescriptive

# Approach 1: Update and Expand 2011 DS



TABLE 9.1 High-Priority [illegible]rch Areas and Topics, Status, Recommended Research, and Outcomes for [illegible]0 and [illegible]

| Topic | Status | 2010-2020 | 2020 and Beyond | Outcomes |
|---|---|---|---|---|
| Flui[illegible] | | | | |
| *Red[illegible] multiphase flows, cryogenics, and heat transfer: database and mod[illegible]* Pha[illegible] distribution, phase-change heat transfer, pres[illegible] mul[illegible] stability. (API)[a] | [illegible]ry limited; [illegible]ualitative, reduced-g[illegible]ty data exist, leading to [illegible]t designer [illegible]. [illegible]reliable detailed sim[illegible]s of reduced-[illegible]hase [illegible]a exis[illegible] | —Design and build a multipurpose phase-change test loop for the fluids integrated rack aboard the International Space Station (ISS).<br>—Acquire targeted database on phase distribution and separation, phase-change heat transfer (e.g., boiling and condensation), pressure drop, and system stability.<br>—Perform detailed direct numerical simulations (DNSs) [illegible] molecular simulations of selected phase distribution, liquid management, cryogenics, and phase-change phenomena at reduced gravity. | —Acquire comprehensive, detailed three-dimensional data on phase distribution and separation and phase-change heat transfer.<br>—Develop mechanistic, multiscale three-dimensional computational multiphase fluid dynamic models (using a reduced-gravity database and DNS or molecular simulation results).<br>—Develop a one-dimensional drift-flux model based on a reduced-gravity database. | —A reliable database with which to develop and assess accurate models for the design and analysis of new and/or significantly improved systems for NASA (e.g., for power production and utilization, waste water recovery, on-orbit fueling, in situ resource utilization (ISRU) extraction of water from surface materials, etc.).<br>—Reliable predictive capabilities for multiphase flow and heat transfer at reduced-gravity levels for system design, scale-up, and analysis. |

Goal: Enable the design of microgravity flow boiling systems that will not exceed critical heat flux under normal or extreme operating conditions (transforms exploration with more smaller thermal management systems)

Scheduling by Decade

What purposes?
What system (e.g., FC-72?)

How are targets chosen?

What besides boiling and condensation?

Stability in response to what perturbations?

Both?

Selected how?

Any *g*-level below 1? (0, 1/6, 3/8)?

How is reliability defined?

How accurate?

Can a minimum, specific set be listed?

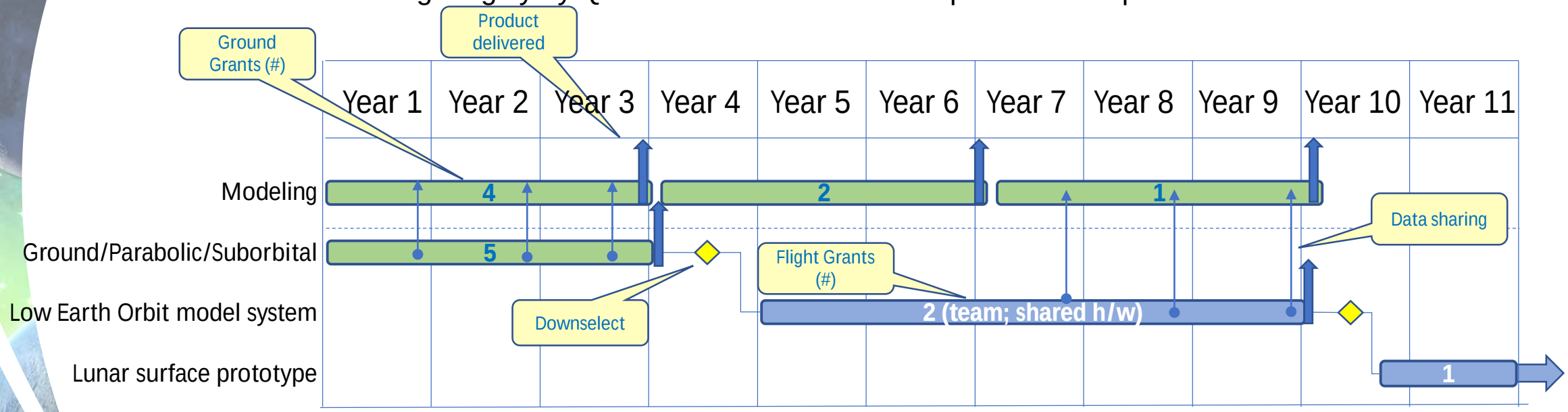
How reliable?

What specific levels?

Scale up from what? to what?

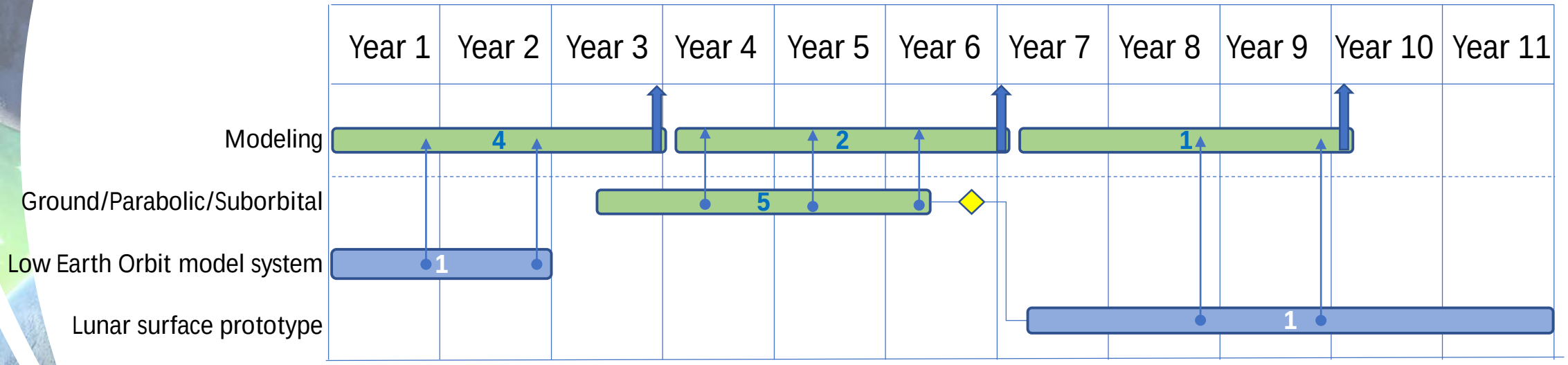
# Campaign for Fluid Physics (1)

- Starting a program in 2011 after receipt of the Decadal Survey
- Addresses subset of Table 9.1: flow boiling, model system (FC-72) for all but lunar surface, 0- and 1/6-*g,* thermal management
- Assumes model development is sufficiently mature in Year 10
- Scheduling roughly by Quarter similar to a NASA implementation plan

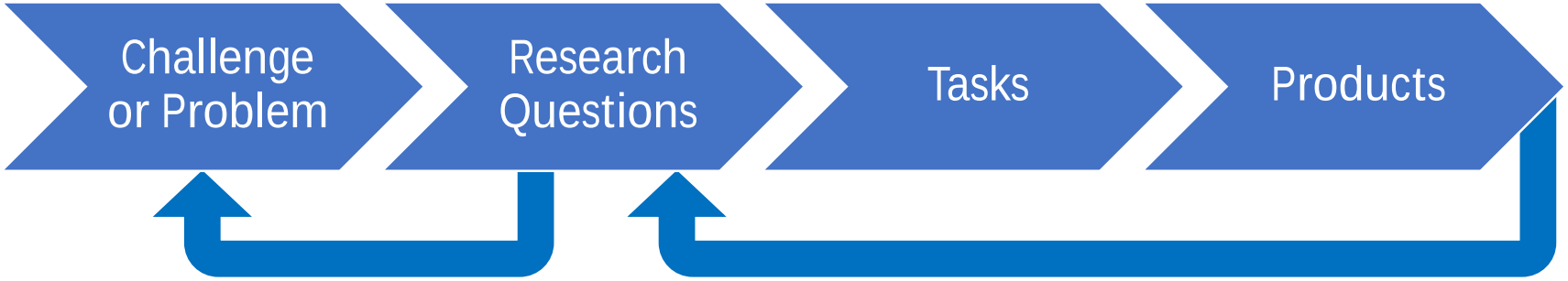


# Campaign for Fluid Physics (2)

- Starting a program in 2023 after receipt of the next Decadal Survey
- Addresses subset of Table 9.1: flow boiling, model system (FC-72) for all but lunar surface, 0- and 1/6-g, thermal management
- Assumes model development is sufficiently mature in Year 10
- Scheduling roughly by Quarter similar to a NASA implementation plan



# Approach 2: A General Schema

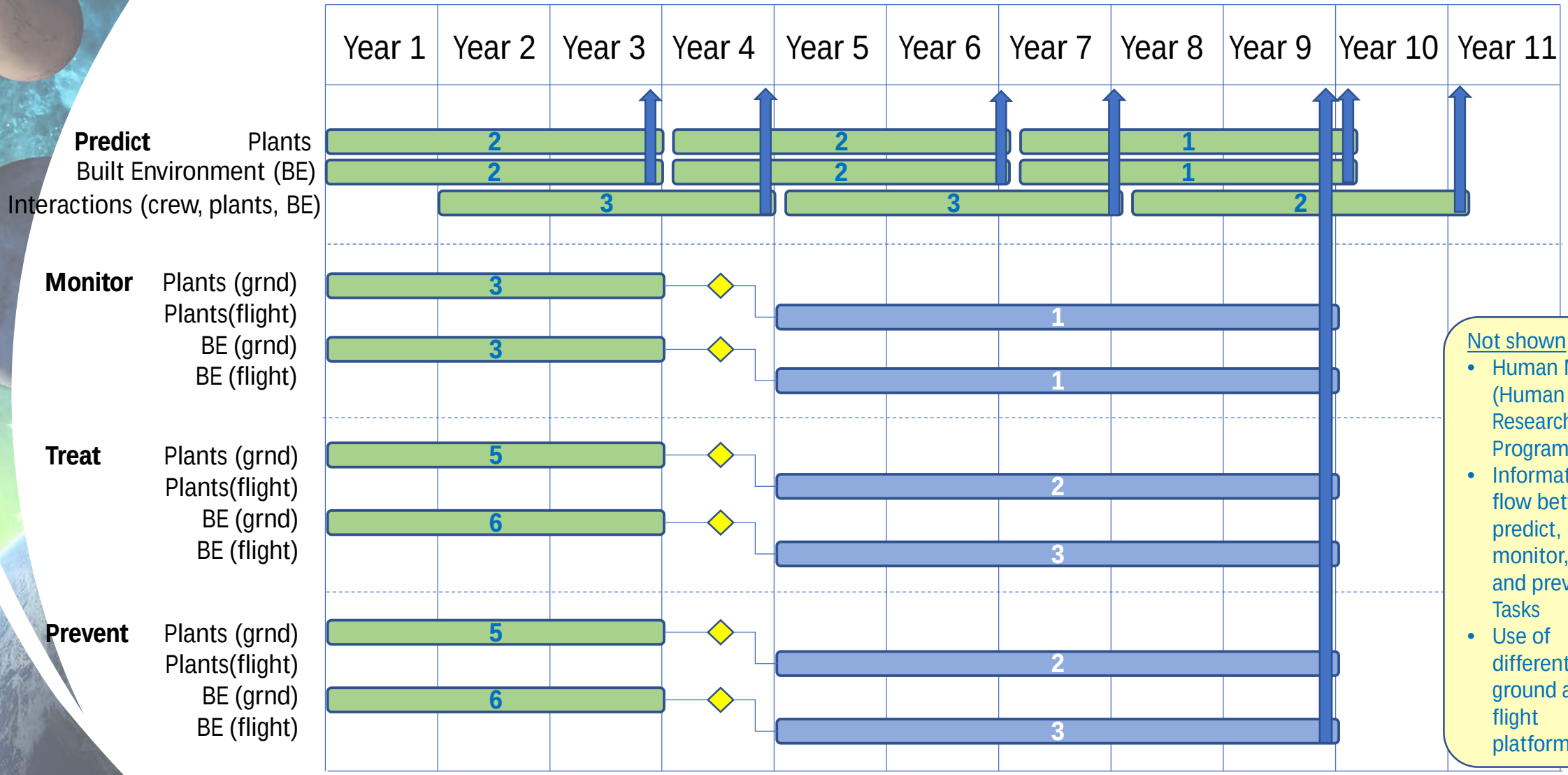



- Captures several related lines of research driven by a Challenge or Problem
  - Challenge or Problem articulated in one sentence
- The Challenge or Problem leads to several Research Questions that need to be answered to address the Challenge or solve the Problem
- Each Research Question leads to several Tasks (i.e., research grants)
  - Some Tasks may address more than one Research Question
- Tasks deliver Products that answer the Research Question (in whole or in part) and thereby help address the Challenge or solve the Problem

# Example: Microbial Ecosystems (ME)

- Challenge: NASA has the knowledge and tools to decide how to manage the microbial ecosystems in a 30-month mission to Mars and back
- Research Questions:
  1. How can we predict future state of microbial ecosystems in mission?
  2. How can we prevent the generation of unhealthy microbial ecosystems?
  3. How can we monitor state of microbial ecosystems in mission?
  4. How can we intervene to change the state of microbial ecosystems in mission?
  - Desire answers in terms of fundamental, mechanistic understanding rather than empirical/phenomenological generalizations
- Additional “dimensions” to the research space
  - Systems: Crew, plants, built environment; interactions between the three
  - Platforms: Earth analogs, ISS, other LEO habitats, Gateway, lunar surface systems (lander, habitat, suit, rover)
- The Research Campaign specifies what subset of Research Questions, systems, and platforms should be studied and in what sequence

# Campaign for Microbial Ecosystems




Not shown

- Human ME (Human Research Program)
- Information flow between predict, monitor, treat, and prevent Tasks
- Use of different ground and flight platforms

# Questions for the Community to Consider

- Are goals appropriate for all transformative areas?
- What is the appropriate temporal resolution of a Research Campaign?
  - The current Decadal uses a decade
  - The examples above use a year (quarter)
- Can the scope of Research Campaigns be well defined without being unnecessarily restrictive?
  - Is it reasonable to specify the number (or range) of awards that should address a research question?
  - What types of teaming arrangements, if any, should be suggested in a Research Campaign?
- How should the health and vitality of a discipline area be nurtured in light of Research Campaigns?
  - Some campaigns may include down-selects that result in decreased support of the discipline
  - Should a balance between the number of ground and flight investigations be maintained throughout the decade?

# *Thank you*

- Learn more about BPS research at science.nasa.gov/biological-physical
- Follow the conversations on social media using #BPSDecadalSurvey.
  - Join us for a Reddit “Ask Me Anything” live panel event on Friday, November 13, 2020, from 1:30-3:30 PM ET
- Connect with colleagues at the American Society for Gravitational and Space Research at https://asgsr.org/

# Reference

# Technology Readiness Levels